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㉓ Coated optical fiber unit.

㉔ A coated optical fiber unit having at least two coated optical fibers each of which has a coloring layer as the outermost layer and which are coated together with a bundling coating layer, in which the bundling coating layer and the coloring layer are both treated to suppress their bonding, by which the coloring layer is not removed at the same time as the removal of the bundling coating layer, the releasing agent added to the bundling coating layer and the coloring layer does not swell the resins in the layers, or cause peeling of the protective coating layer from the optical fiber.

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BACKGROUND OF THE INVENTIONField of the Invention

5 The present invention relates to a coated optical fiber unit comprising at least two fibers which are coated together with a bundling coating layer, and each of which has a protective coating layer around an optical fiber. In particular, the present invention relates to improvement of a resin of a bundling coating layer and a coloring layer.

10 Description of the Related Art

Since an optical glass fiber to be used as an optical transmission medium (hereinafter referred to as "optical fiber") has a diameter of 150  $\mu\text{m}$  or less usually, and is made of a fragile material, namely glass, its surface tends to be easily flawed during its production or cable assembling, or storage, and the stress is 15 concentrated on the flawed part so that the optical fiber is easily broken when an external force is applied thereon.

Since it is very difficult to use the optical fiber as such as an optical transmission medium, the surface of optical fiber is coated with a resin to maintain an initial strength just after the production and to be worthy for long term use, and the coated optical fiber is practically used.

20 Examples of the conventionally used resinous coating material are thermosetting resins (e.g. silicone resin, epoxy resin, urethane resin, etc.), actinic ray (UV light)-curable resins (e.g. polyepoxy acrylate, polyurethane acrylate, polyester acrylate, etc.), and the like. Since these materials are organic materials, it is known that they suffer from denaturation such as oxidation, or deterioration. To prevent denaturation, they are treated to suppress the generation of hydrogen gas ( $\text{H}_2$ ) as disclosed in Japanese Patent KOKAI 25 Publication No. 113711/1989.

To improve the handling easiness and a density of the optical fibers, a coated optical fiber unit in which two or more coated optical fibers are coated together with a bundling coating layer.

When the single optical fiber of the coated optical fiber unit is fusion connected with an optical fiber or the single optical fiber of other coated optical fiber unit, or with a connector, an end part of the bundling 30 coating resin should be removed to separate the single optical fibers. Each coated optical fiber has a coloring layer around the protective coating layer to identify each optical fiber when it is separated as above.

When a bond strength between the bundling coating resin and the coloring layer is larger than that between the coloring layer and the protective coating layer, the coloring layer is removed when the 35 bundling protective resin is removed, so that the respective optical fiber may not be identified.

To solve such problem, Japanese Patent KOKAI Publication Nos. 281109/1988 and 57814/1992 disclose either one of the bundling coating resin and the coloring layer is treated to suppress bonding, whereby the bond strength between the bundling coating resin and the coloring layer is decreased.

However, to decrease the bond strength by the above treatment for suppressing bonding, a releasing 40 agent should be added to the resin or the coloring layer at a high concentration. If the releasing agent is added at a high concentration, it will cause various problems since it is a low molecular compound and easily moves in the bundling coating layer, coloring layer and protective coating layer which are made of polymers.

When the releasing agent migrates to the inner resin of the coloring layer, the resin swells and finally 45 the resin layer is cracked. When the releasing agent migrates to an interface between the optical fiber and the protective coating layer, a part of the protective layer is peeled off from the optical fiber, and the releasing agent which is accumulated between the protective coating layer and the optical fiber generates uneven stress on the optical fiber, which may increase transmission loss.

When the releasing agent migrates onto the surface of the bundling coating layer, the surface of the 50 bundling coating resin becomes sticky so that the handling property of the unit is deteriorated. In addition, the releasing agent aggregates to cause phase separation in the resin.

The bonding between the bundling coating layer and the coloring layer is formed since the surfaces of the bundling coating resin and the coloring layer are adhesion active physically (e.g. unevenness) or chemically (e.g. presence of functional groups which form a hydrogen bond).

55 The above treatment for suppressing bonding is aimed to make one of the bundling coating layer surface and the coloring layer surface adhesion inactive. Since the resin of the other layer is still adhesion active on its surface in the above treatment, the releasing agent should be added to one resin in a very high concentration such that the surface of the other resin is made adhesion inactive, when the bonding is

suppressed by the addition of the releasing agent. Otherwise, no effect is obtained.

#### SUMMARY OF THE INVENTION

5 An object of the present invention is to provide a coated optical fiber unit in which at least two coated optical fibers each of which has a coloring layer are coated together with a bundling coating layer, and the coloring layer is not peeled off when the bundling coating layer is removed.

10 According to the present invention, there is provided a coated optical fiber unit comprising at least two coated optical fibers each of which has a coloring layer as the outermost layer and which are coated together with a bundling coating layer, wherein said bundling coating layer and said coloring layer are both treated to suppress their bonding.

15 In a preferred embodiment, each of the bundling coating layer and the coloring layer contains 5 % by weight or less of a releasing agent based on the weight of each layer. Preferably, the releasing agent is a silicone releasing agent or a fluorine base releasing layer.

20 In another preferred embodiment, at least two coated optical fibers are intertwined around a tension member, or they are arranged in parallel.

#### BRIEF DESCRIPTION OF THE DRAWINGS

20 Fig. 1 is a cross sectional view of one embodiment of the coated optical fiber unit according to the present invention, and

Fig. 2 is a cross sectional view of another embodiment of the coated optical fiber unit according to the present invention.

25 DETAILED DESCRIPTION OF THE INVENTION

The present invention will be explained further in detail by making reference to the accompanying drawings, which do not limit the scope of the present invention in any way.

In Fig. 1, a coated optical fiber Unit of the present invention comprises a tension member 15 and six coated optical fibers, each of which comprises an optical fiber 13, a coating layer 14 and a coloring layer 12 as the outermost layer, and which are intertwined around the tension member 15. The coated optical fibers are further coated with a bundling coating layer 11.

In this structure, the bond strength between the bundling coating layer 11 and the coloring layers 12 which contact to the inner surface of the bundling coating layer 11 is important. When this bond strength is smaller than that between the coloring layers 12 and the protective coating layers 14, the coloring layers 12 are not peeled off when the bundling coating layer 11 is removed.

In Fig. 2, the coated optical fiber unit of the present invention comprises the coated optical fibers which are arranged in parallel and coated with a bundling coating layer 24. Each of optical fibers is coated with a protective coating layer 22 and a coloring layer 21 as the outermost layer.

40 In this structure, the bond strength between the bundling coating layer 24 and the coloring layers 21 which contact to the inner surface of the bundling coating layer 24 is important. When this bond strength is smaller than that between the coloring layers 21 and the protective coating layers 22, the coloring layers 21 are not peeled off when the bundling coating layer 24 is removed.

45 A kind of the releasing agent is not limited. Usually, a silicone resin or oil, or a fluororesin or fluoro-oil is used. Such releasing agents are well known in the art. The silicone resin or oil and the fluororesin or fluoro-oil are an organic compound having at least one silicon or fluorine atom in a molecule, and the silicone resin or fluororesin can be cured by heat or light.

50 A concentration of the releasing agent is usually 5 % by weight or less, preferably 3 to 0.7 % by weight, more preferably 2 to 0.5 % by weight, based on the weight of the bundling coating layer or the coloring layer. In such concentration range of the releasing agent, the coloring layer is not removed at the same time as the removal of the bundling coating layer, the releasing agent which is added to the bundling coating layer and the coloring layer does not swell the resins in the layers, or cause peeling of the protective coating layer from the optical fiber.

55 The coloring layer is used to identify each coated optical fiber. Usually, the coloring layer is made of a resin which is colored with a solvent type ink or a UV-light curable ink, or by kneading a pigment in the resin.

Preferred examples of the resin used to form the coloring layer are thermosetting resins (e.g. silicone resins, epoxy resins, urethane resins, etc.), radiation (UV light)-curable resin (e.g. polyepoxy acrylate,

polyurethane acrylate, polyester acrylate, etc.) and the like.

Preferred examples of the resin used to form the protective coating layer or the bundling coating layer are thermosetting resins (e.g. silicone resin, epoxy resin, urethane resin, etc.), actinic ray (UV light)-curable resins (e.g. polyepoxy acrylate, polyurethane acrylate, polyester acrylate, etc.), and the like.

5 The resin of the coating layer(s) may contain at least one additive such as a light stabilizer, an antioxidant, a UV light absorber, a lubricant, a flame retardant, a filler, a pigment, and the like, if necessary.

Thicknesses of the protective layer and the coloring layer may be the same as those employed in the conventional optical fiber unit.

10 A thickness of the bundling coating layer is also the same as that employed in the conventional optical fiber unit. For example, it is from 5 to 100  $\mu\text{m}$ .

#### PREFERRED EXAMPLES OF THE INVENTION

15 The present invention will be illustrated by the following examples.

##### Example 1

A coated optical fiber unit having the structure of Fig. 1 was produced.  
Each of the coated optical fibers was produced by heating a glass preform in a drawing furnace to melt  
20 and draw it to form an optical fiber and coating its surface with a protective resin.

As a resin of a coloring layer, a UV light-curable polyurethane acrylate resin containing a silicone oil or a fluoro-oil in varying concentrations shown in Table 1 was used, and coated around the coated optical fiber in a usual manner.

25 The coated optical fiber unit of Fig. 1 was produced as follows:  
The six coated optical fibers each having the coloring layer were intertwined around a tension member.  
Then, the entire peripheral surface of the intertwined optical fibers was coated with a bundling coating resin.  
Then, the peeling of the coloring layer was examined as follows:  
From each of the coated optical fiber units A to K each having six coated optical fibers, an end part (20 cm) of the bundling coating layer was removed.  
30 Along the total removing length (20 cm  $\times$  6 optical fibers = 120 cm), the total length of the coloring layers which were peeled off from the optical fibers was measured, and the degree of peeling of was evaluated.  
With the coated optical fiber units, the peeling off of the coloring layers, the peeling between the optical fiber and the protective coating layer, cracking of the protective coating layer and the tackiness of the  
35 bundling protective layer surface were evaluated. The results are shown in Table 1.

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Table 1

Coated optical fiber unit	Releas- ing agent	Concentration of releasing agent		Degree of peeling of coloring layer (cm)	Peeling between optical fiber and protective coating	Cracking of protective coating layer	Tackiness of bundling coating layer surface
		in bundling coating layer (wt. %)	in coloring layer (wt. %)				
A	(None)	0	0	2.5	No	Yes	No
B	Sili- cone oil	10	0	3	No	No	Slightly
C	↑	20	0	0	Yes	Yes	No
D	↑	0	10	6	Slightly	No	No
E	↑	0	20	1	Yes	Yes	No
F	↑	2	2	0.5	No	No	No
G	↑	5	5	0	No	No	No
H	Fluoro- oil	0	10	5	Slightly	No	No
I	↑	10	0	5	No	No	Slightly
J	↑	3	3	0	No	No	No
K	↑	5	5	0	No	No	No

As seen from the results in Table 1, the degree of peeling of the coloring layer is decreased by the addition of the releasing agent to the bundling coating layer and the coloring layer.

As in the case of the coated optical fiber units C and E, when the releasing agent is added to only one of the bundling coating layer and the coloring layer, the concentration of the releasing agent should be 20 % by weight or larger to prevent the peeling off of the coloring layer.

However, when the releasing agent is used in a high concentration as in the coated optical fiber units C and E, the releasing agent in the coloring layer migrates in the resin of the inner part to swell the resin, whereby the resin is cracked, or the releasing agent migrates in the protective coating layer, whereby the protective coating layer is partly peeled off from the optical fiber.

5 In addition, when the releasing agent migrates onto the surface of the bundling coating layer, the surface is made tacky so that the handling of the coated optical fiber unit becomes difficult.

As seen from the results of the coated optical fiber units F, G, J and K, the releasing agent is added to both of the bundling coating layer and the coloring layer, the peeling off of the coloring layer can be prevented even at a concentration of 5 % by weight or less.

10 Accordingly, it is preferred to add the releasing agent to both of the bundling coating layer and the coloring layer at the concentration of 5 % by weight or less each to provide the coated optical fiber unit in which the coloring layer is not removed at the same time as the removal of the bundling coating layer, the releasing agent added to the bundling coating layer and the coloring layer does not swell the resins in the layers, or cause peeling of the protective coating layer from the optical fiber.

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#### Example 2

A coated optical fiber unit having the structure of Fig. 2 was produced.

The coated optical fibers were produced in the same way as in Example 1.

20 As a resin of a coloring layer, a UV light-curable polyurethane acrylate resin containing a silicone oil or a fluoro-oil in varying concentrations shown in Table 2 was used, and coated around the coated optical fiber.

The coated optical fiber unit of Fig. 2 was produced as follows:

25 The four coated optical fibers arranged in parallel and the entire periperal surface was coated with a bundling coating resin.

Then, the peeling of the coloring layer was examined as follows:

From each of the coated optical fiber units L to V each having four coated optical fibers, an end part (20 cm) of the bundling coating layer was removed.

30 Along the total removing length (20 cm x 4 optical fibers = 80 cm), the total length of the coloring layers which were peeled off from the optical fibers was measured, and the degree of peeling of was evaluated.

With the coated optical fiber units, the peeling off of the coloring layers, the peeling between the optical fiber and the protective coating layer, cracking of the protective coating layer and the tackiness of the bundling protective layer surface were evaluated. The results are shown in Table 2.

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Coated optical fiber unit	Releasing agent	Concentration of releasing agent		Degree of peeling of coloring layer (cm)	Peeling between optical fiber and protective coating	Cracking of protective coating layer	Tackiness of bundling coating layer surface
		in bundling coating layer (wt. %)	in coloring layer (wt. %)				
L	None	0	0	18	No	No	No
M	Silicone oil	10	0	2	No	No	Slightly
N	↑	20	0	0	Yes	Yes	Yes
O	↑	0	10	4	Slightly	No	No
P	↑	0	20	1	Yes	Yes	Yes
Q	↑	3	3	0	No	No	No
R	↑	5	5	0	No	No	No
S	Fluoro-oil	0	10	5	Slightly	No	No
T	↑	10	0	4	No	No	Slightly
U	↑	2	2	0	No	No	No
V	↑	5	5	0	No	No	No

As seen from the results in Table 2, the degree of peeling of the coloring layer is decreased by the addition of the releasing agent to the bundling coating layer and the coloring layer.

As in the case of the coated optical fiber units N and P, when the releasing agent is added to only one of the bundling coating layer and the coloring layer, the concentration of the releasing agent should be 20 % by weight or larger to prevent the peeling off of the coloring layer.

However, when the releasing agent is used in a high concentration as in the coated optical fiber units N and P, the releasing agent in the coloring layer migrates in the resin of the inner part to swell the resin, whereby the resin is cracked, or the releasing agent migrates in the protective coating layer, whereby the protective coating layer is partly peeled off from the optical fiber.

5 In addition, when the releasing agent migrates onto the surface of the bundling coating layer, the surface is made tacky so that the handling of the coated optical fiber unit becomes difficult.

As seen from the results of the coated optical fiber units Q R, U and V, the releasing agent is added to both of the bundling coating layer and the coloring layer, the peeling off of the coloring layer can be prevented even at a concentration of 5 % by weight or less.

10 Accordingly, it is preferred to add the releasing agent to both of the bundling coating layer and the coloring layer at the concentration of 5 % by weight or less each to provide the coated optical fiber unit in which the coloring layer is not removed at the same time as the removal of the bundling coating layer, the releasing agent added to the bundling coating layer and the coloring layer does not swell the resins in the layers, or cause peeling of the protective coating layer from the optical fiber.

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### Claims

1. A coated optical fiber unit comprising at least two coated optical fibers each of which has a coloring layer as the outermost layer and which are coated together with a bundling coating layer, wherein said bundling coating layer and said coloring layer are both treated to suppress their bonding.
2. The coated optical fiber unit according to claim 1, wherein said treatment to suppress bonding comprises the addition of a releasing agent.
- 25 3. The coated optical fiber unit according to claim 2, wherein a concentration of said releasing agent is not larger than 5 % by weight based on the weight of said bundling coating layer or said coloring layer.
4. The coated optical fiber unit according to claim 2, wherein said releasing agent is at least one material selected from the group consisting of silicone releasing agents and fluorine base releasing agents.
- 30 5. The coated optical fiber unit according to claim 1, which further comprises a tension member, and said coated optical fibers are intertwined around said tension member.
6. The coated optical fiber unit according to claim 1, wherein said coated optical fibers are arranged in parallel.

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FIG. 1

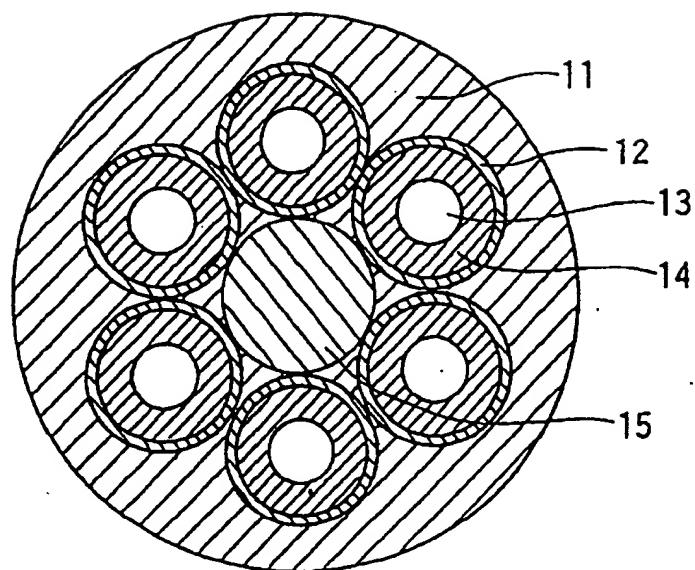
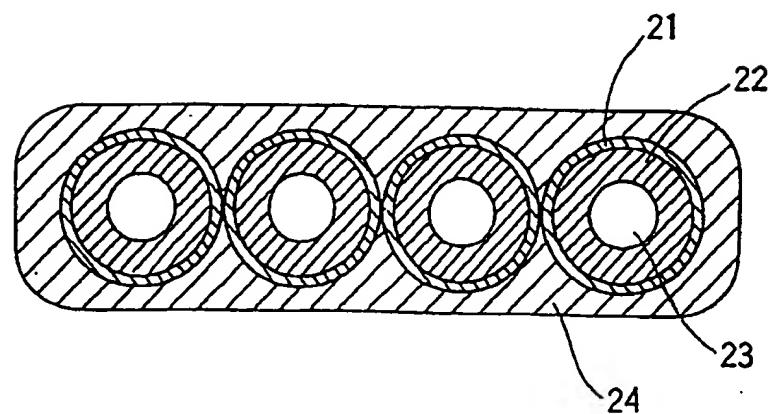


FIG. 2





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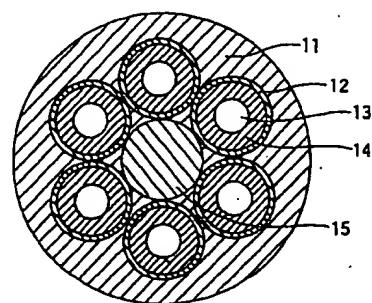
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㉔ Coated optical fiber unit

㉕ A coated optical fiber unit having at least two coated optical fibers (13,14) each of which has a coloring layer (12) as the outermost layer and which are coated together with a bundling coating layer (11), in which the bundling coating layer and the coloring layer are both treated to suppress their bonding, by which the coloring layer is not removed at the same time as the removal of the bundling coating layer, the releasing agent added to the bundling coating layer and the coloring layer does not swell the resins in the layers, or cause peeling of the protective coating layer from the optical fiber.

FIG. 1



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EUROPEAN SEARCH REPORT

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EP 94 10 3211

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.CLS)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	EP-A-0 349 206 (AMERICAN TELEPHONE AND TELEGRAPH COMPANY) * claims 1,4 *	1	G02B6/44
D,X	PATENT ABSTRACTS OF JAPAN vol. 13, no. 102 (P-841) 10 March 1989 & JP-A-63 281 109 (SUMITOMO ELECTRIC INDUSTRIES) 17 November 1988 * abstract *	1	
A	EP-A-0 262 340 (SUMITOMO ELECTRIC INDUSTRIES) * column 4, line 35-50 *	1-4	
A	EP-A-0 418 829 (SUMITOMO ELECTRIC INDUSTRIES) * page 2, line 44-53 *	2,3	
A	PATENT ABSTRACTS OF JAPAN vol. 7, no. 198 (P-220) 2 September 1983 & JP-A-58 098 707 (NIPPON DENSHIN DENWA KOSHA) 11 June 1983 * abstract *	2-4	TECHNICAL FIELDS SEARCHED (Int.CLS)
A	PATENT ABSTRACTS OF JAPAN vol. 14, no. 223 (P-1046) 11 May 1990 & JP-A-02 051 108 (SUMITOMO ELECTRIC INDUSTRIES) 21 February 1990 * abstract *	2	G02B
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
BERLIN	12 April 1995	Fuchs, R	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application I : document cited for other reasons A : member of the same patent family, corresponding document	
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